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A framework to investigate drivers of adaptation decisions in marine fishing: Evidence from urban, semi-urban and rural communities

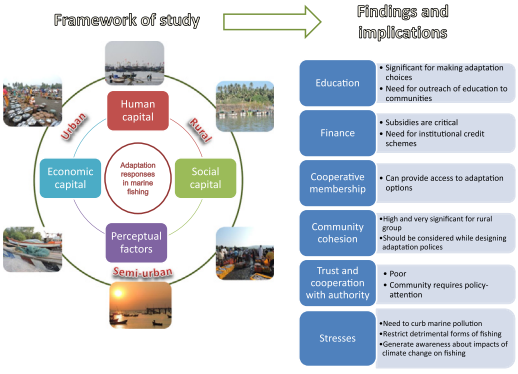
Krishna Malakar [a,*], Trupti Mishra [a,b], Anand Patwardhan [c]

[a] Interdisciplinary Program (IDP) in Climate Studies, Indian Institute of Technology Bombay, Mumbai, Maharashtra 400076, India
[b] Shailesh J. Mehta School of Management, Indian Institute of Technology Bombay, Mumbai, Maharashtra 400076, India
[c] School of Public Policy, University of Maryland, MD 20742, USA

HIGHLIGHTS

- Human, economic, social and perceptual drivers of adaptation decisions are assessed
- Some drivers differ regionally, e.g., community cohesion can influence adaptation decisions specifically in rural region
- Special credit schemes having liberal conditions of eligibility are required
- Need to develop trust of fisherfolk on government authorities through community-engagement
- Redesigning and implementing existing policies can substantially aid capacity-building

GRAPHICAL ABSTRACT



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ABSTRACT

Traditional fishing livelihoods need to adapt to changing fish catch/populations, led by numerous anthropogenic, environmental and climatic stressors. The decision to adapt can be influenced by a variety of socio-economic and perceptual factors. However, adaptation decision-making in fishing communities has rarely been studied. Based on previous literature and focus group discussions with community, this study identifies few prominent adaptation responses in marine fishing and proposes credible factors driving decisions to adopt them. Further, a household survey is conducted, and the association of these drivers with various adaptation strategies is examined among fisherfolk of Maharashtra (India). This statistical analysis is based on 601 responses collected across three regional fishing groups: urban, semi-urban and rural. Regional segregation is done to understand variability in decision-making among groups which might be having different socio-economic and perceptual attributes. The survey reveals that only few urban fishing households have been able to diversify into other livelihoods. While having economic capital increases the likelihood of adaptation among urban and semi-urban communities, rural fishermen are significantly driven by social capital. Perception of climate change affecting fish catch drives adoption of mechanized boats solely in urban region. But increasing number of extreme events affects decisions of semi-urban and rural fishermen. Further, rising pollution and trade competition is associated with adaptation responses in the urban and semi-urban community. Higher education might help fishermen choose convenient forms of adaptation. Also, cooperative membership and subsidies are critical in adaptation decisions. The framework and insights of the study suggest the importance of acknowledging differential decision-making of individuals and communities, for designing effective adaptation and capacity-building policies.

* Corresponding author at: IDP in Climate Studies, Room no. 319, Pre-engineering building, Indian Institute of Technology Bombay, Mumbai, Maharashtra 400076, India.
E-mail addresses: krishna.malakar@iitb.ac.in krishnamalakar26@gmail.com (K. Malakar), truptimishra@iitb.ac.in, (T. Mishra), apat@umd.edu (A. Patwardhan).

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1. Introduction

Climatic, environmental and other human-induced stresses, such as pollution and acidification, have severely altered the marine environment, leading to changes in fish population and distribution (Halpern et al., 2008; Hoegh-Guldberg and Bruno, 2010). Consequently, fish catch appear to be declining (Chassot et al., 2010; Golden et al., 2016), making it crucial for fishing dependent livelihoods to adapt. Climate change is projected to lower fish catch by 38%, and associated revenue by 33%, around the tropics by mid-century (Lam et al., 2016). In Asia, India's marine fishing sector is one of the most sensitive to impacts of climate change, majorly because of the country's nutritional and economic dependence on marine fishing, as well as the poor socio-economic condition of its fishing community (Allison et al., 2005). In 2015, India experienced a 5.3% drop in total fish landings compared to the past year, and a sharp decline of 50% in oil sardines, which is one of the main fish species around the Indian coastline (FRAD CMFRI, 2016). Ecosystem management, through state and community governance, is important for maintaining ocean biodiversity and species population. But individual adaptation/intensification responses, such as using improved gear and changing fishing strategies, are also critical for sustaining fish catch and returns from traditional marine livelihoods (Blythe et al., 2014; Grafton, 2010; Vivekanandan, 2011). Dwindling fish catch may also lead fisherfolk to diversify into other sources of livelihood. Further, as extreme events in the sea pose serious occupational risk to the community, adaptation strategies (such as insuring fishing gear) that can improve resilience are also needed (Badjeck et al., 2010).

The decision to undertake various adaptation strategies can be influenced by a host of social, economic and perceptual factors (Adger et al., 2005; Deng et al., 2017; Grothmann and Patt, 2003), which consequently leads to differential responses among individuals of a community. Understanding the drivers of various adaptation decisions can substantially help in designing policy directives for capacity-building of communities. Although marine fishing is a vulnerable source of livelihood with a dependence of around 260 million people around the globe (Teh and Sumaila, 2013), assessments of determinants of adaptation have rarely been attempted in previous studies. This study proposes a framework to identify the drivers of adaptation responses in marine fishing communities. While such frameworks are almost lacking for fishing communities in the extant literature, there are a number of studies which have analyzed the drivers of adaptation in agricultural communities and have described their implication for adaptation policy (Below et al., 2012; Comoé and Siegrist, 2013; Deressa et al., 2009; Jain et al., 2015; Yegbemey et al., 2013). It is observed that such frameworks can be useful for specifically recognizing and targeting factors, which can assist adaptation, during interventions.

There are various studies which have qualitatively or quantitatively explored adaptation and adaptive capacity of marine fishing communities. Allison and Ellis (2001) suggested understanding adaptation in fishing communities through the lens of Sustainable Livelihoods Approach (SLA) or capitals approach. However, the paper focused mostly on fishery management practices rather than household/individual adaptation. The vulnerability of fisheries sector around the world to climate change was quantified through country-level indices on risk, sensitivity and adaptive capacity by Allison et al. (2005). There are studies which have developed community-level vulnerability indices through primary surveys as well (Cinner et al., 2015; Islam et al., 2014a; Metcalf et al., 2015; Morzaria-Luna et al., 2014; Senapati and Gupta, 2017). Again, Allison and Horemans (2006) used SLA to develop interventions to capacitate, adapt and fight poverty in fishing communities. There are also other qualitative studies which provide insights into the assets/capitals (from SLA) required for adaptation in fishing communities (Blythe et al., 2014; Divakarannair, 2007; Islam et al., 2014b; Iwasaki et al., 2009; Tuler et al., 2008). However, all these studies do not statistically investigate the relevant drivers of adaptation responses. Members of communities can make different adaptation decisions based on their differential capabilities. Thus, the current study attempts to contribute to the literature in two ways. First, the proposed framework which is particularly tailored for marine fishing communities can impart understanding which factors influence adaptation and why fishermen respond differentially. The framework also attempts to give attention to multi-stressors impacting fish catch and fishing livelihoods — by considering fishermen's perceptions of pollution, trade competition and climate change as determinants of adaptation decisions. The framework initially draws upon previous studies which have recognized and described factors/capitals that can induce adaptation in marine fishing as well as other communities around the world. Thereafter, the variables of the framework are refined and finalized based on focus group discussions (FGD) with the community. Primarily, the paper aims to bring together a number of probable drivers of adaption, set them up in a statistical model and test hypotheses to infer the factors which might initiate fishing communities to adapt.

Secondly, the study identifies the predominant adaptation strategies and applies the framework to understand their drivers in fishing communities located in urban, semi-urban and rural areas of Maharashtra, India. Regional segregation of fishing communities, which is not evident in previous studies, is done to envisage whether factors influencing adaptation vary across regional groups. Marine fishing is conducted in the seas and activities, such as docking and fish drying, do not require much land area. Thus, traditional fishing settlements can be found along coastlines of rural, semi-urban as well as urban areas. These communities might have varying levels of access to capitals and their influence on decisions may differ. Urban communities might have better access to human and economic capital such as education and formal credits/banks (Iqbal and Sami, 2017; OECD, 2013). Communities in urban and rural areas might also differ with respect to available social networks (Debertin, 1997). Urban fishermen might be better informed about improved technology and gear as well as have more diversification opportunities. Further, the communities' surroundings might lead to different perceptions about changes, for example, urban fishermen might be experiencing pollution since a longer time than the other two communities. Socio-economic differences between urban and rural communities can be especially pertinent in developing countries, such as India (Fan et al., 2005; Sahn and Stifel, 2004; Sarkar and Mehta, 2010). Thus, it is worth investigating the drivers of adaptation separately for the three communities with different regional backdrops. It can offer further understanding of decision-making in groups, possibly having varied assemblage of socio-economic factors. Consequently, this may be useful for designing appropriate policy measures for building adaptive capacity of communities with common livelihoods but different (socio-economic/regional) backgrounds.

The next section describes the methodology, including the framework, adopted in the study. Section 3 presents the empirical results and discusses some of its implications. The study is concluded in Section 4.

2. Methodology

This study focuses on understanding adaptation decisions among the fishing community of Maharashtra, India. Maharashtra is a coastal state in western India bordering the Arabian Sea and has one of the longest coastlines in the country (GoI, 2013). There are fishing villages almost along its entire coastline. However, Maharashtra has been experiencing a declining fish catch and warming, by approximately 1 °C (in 2005 compared to 1950's) along its coast, which can further adversely impact fish populations (ICOR, 2015; Vivekanandan et al., 2009). Fish landing in Maharashtra declined by 5.4% in 2014 and further lowered by 23.1% in 2015 compared to the previous year (CMFRI, 2015, 2014, 2013). This makes the livelihoods of the marine fishing community in Maharashtra vulnerable.

Multiple methods are used to hypothesize the drivers of adaptation, as well as to obtain both qualitative and quantitative insights from the

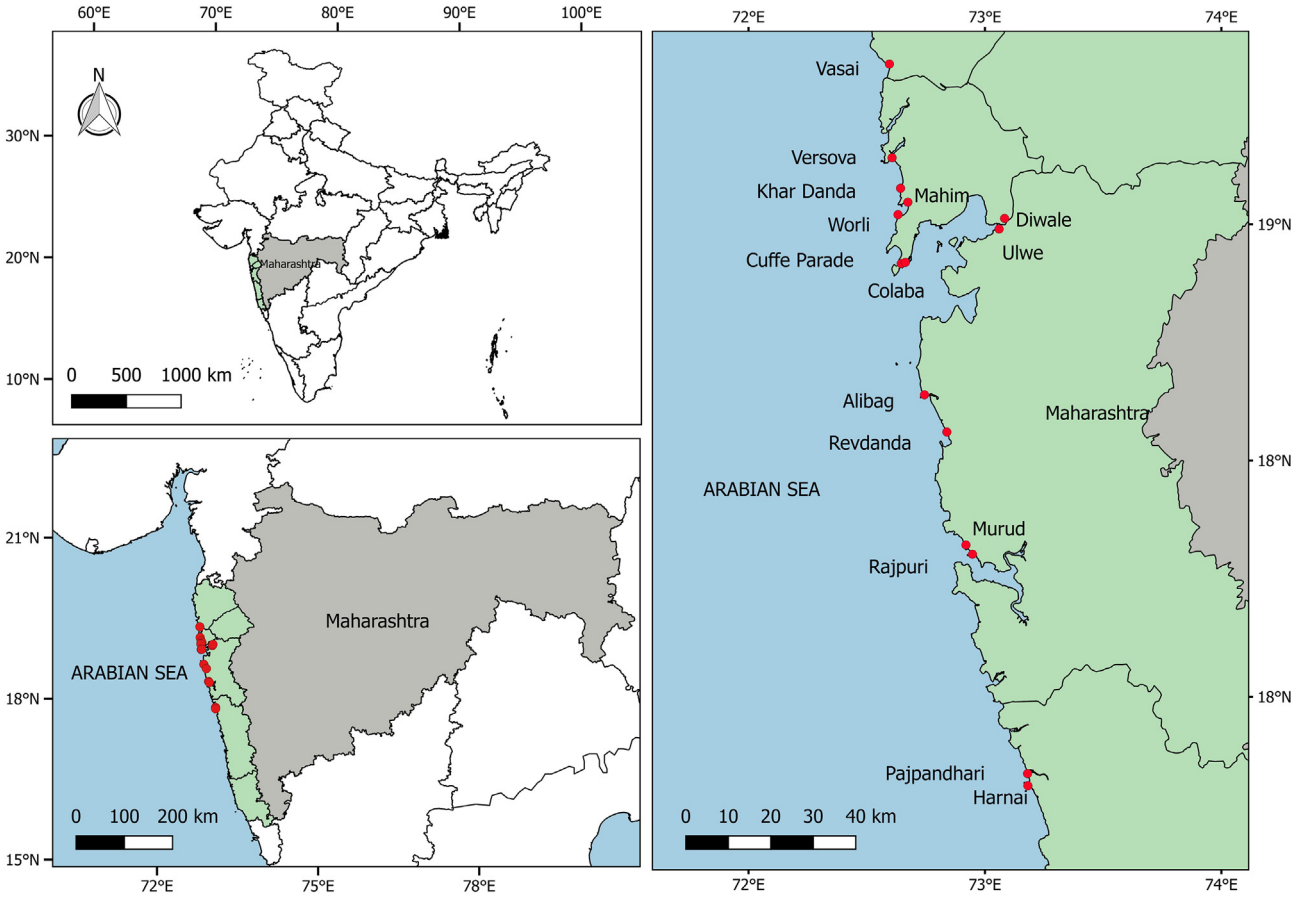

Fig. 1. Map showing the FGD and survey sites (The state of Maharashtra and its coastal districts are highlighted).

study. Literature review, exploratory field visits, discussion with experts, focus group discussions (FGD) and household surveys of the communities contribute to building the study.

2.1. Establishing the framework: from literature and focus group discussions

A review of the literature is done to develop the framework to understand decision-making among marine fishing communities. First, adaptation responses prevalent among marine communities are identified. Second, the plausible drivers of decisions to adopt these strategies are proposed.

Thereafter, three FGDs are held, one each with urban (in Versova), semi-urban (in Ulwe) and rural (in Murud) community in Maharashtra, to understand the communities' adaptation strategies and their perspectives on the limits to adaptation (Map in Fig. 1). Only traditional fishermen, who have been involved in fishing since generations, were included in the discussions. Each focus group comprised of 10–15 fishermen with ages ranging from 30 to 65 years.

2.1.1. Adaptation responses

Fish populations and catch appear to be dwindling around the globe (Golden et al., 2016). Sustaining fishing livelihoods calls for strategies which can maintain fish catch and income. Thus, measures which help improve fish catch/income of fisherfolk are termed as adaptation responses in the study. The literature cites that using improved gear, fishing over large areas, changing fishing location and working longer are commonly adopted strategies to improve fish catch (Blythe et al., 2014; Grafton, 2010; Islam et al., 2014a; Senapati and Gupta, 2017). The changes in fishing habits and strategies adopted by the fishermen specific to the study area, as well as any overlaps with the strategies mentioned in the literature are understood through the three FGDs. Finally, the study identifies four intensification[1] adaptation strategies which are prominent in the area, and might help improve fishermen's catch and livelihood. The first two are regarding use of better gear, that is, having improved boats– motorized and mechanized, and use of multiple types of nets. It is to be noted that mechanized boats are considered to be advanced as well as significantly costlier than motorized ones. Motorized boats are limited to having engines, mostly fuelled by diesel, for propulsion. Mechanized boats are generally larger in size and in addition to engines, they are equipped with fishing gear which helps to mechanically cast nets and perform other related activities. Such boats are also safer during extreme events, such as storms and cyclones, in the sea.

The other two strategies are: working longer hours and going farther in the sea compared to 10–15 years earlier. A timeline of 15 years was chosen based on findings from the FGDs with the communities considered in the study. The communities perceive that they have been experiencing major changes in fish catch since the last 8–15 years. This timeline also proved to be practical while interrogating respondents, having wide range of years of involvement in fishing, about changes based on their experience/memory.

Additionally, insuring boats can reduce economic risks and improve resilience from extreme events (Iwasaki et al., 2009). Fishermen are often threatened by storms and cyclones in the sea. Hence, having boat insurance is also an important adaptation strategy.

Further, household diversification can be a secondary adaptation response in the community to supplement income (Blythe et al., 2014).

[1] Strategies which involve putting more effort in one's primary source of livelihood to improve yields

Thus, the study assesses six adaptation strategies including diversification. Again, the adaptation strategies are not mutually exclusive. For example, a fisherman having mechanized boat might also be using multiple types of nets.

2.1.2. Factors influencing adaptation

The decision to implement strategies to improve livelihoods can be guided by a number of socio-economic and perceptual factors. There are various studies which argue the importance of these factors for building adaptive capacity. The literature widely demonstrates that human capital, such as education and experience in a profession, can improve access to information and knowledge, thus helping to make adaptation choices (Becker, 1994; Below et al., 2012). Previous studies on agricultural communities find significant contribution of finances to adaptation decisions (Below et al., 2012; Deressa et al., 2009; Jain et al., 2015). Similarly, fishing adaptation strategies, such as buying improved boats and gear, can be financially intensive. Economic capital in the form of savings, credits and assets can capacitate individuals to adopt such strategies (Islam et al., 2014a; Senapati and Gupta, 2017). Studies on various communities have proposed social networks and support, such as having relatives/friends, trust and cooperation among community and with authority, to be pertinent for adaptation (Adger, 2003; Jones and Boyd, 2011; Pelling and High, 2005). Perceptual factors about changes and risks affecting livelihoods can also make communities adapt (Grothmann and Patt, 2003).

Based on these insights from the literature, a framework is built which assembles various determinants of adaptation decisions among marine fishermen. This study draws its selection of potential drivers of adaptation from the wide literature on adaptation and adaptive capacity. The drivers/variables are also heavily based on the limited qualitative and quantitative studies on adaptation in fishing communities around the world. Further, findings from the FGDs were used to have assertion regarding the relevance of these factors in the communities considered in the study. This helped in finalizing the determinants hypothesized to affect adaptation decisions in the communities. Table 1 lists the drivers of adaptation explored in the paper along with its particular reasoning and references from the literature. All these drivers are hypothesized (in Table 1) to be positively associated with the decision to adopt strategies listed in Section 2.1.1, except for diversification. Few variables such as access to subsidies, number of household members who stay back, trust and cooperation with authority, membership in fishing cooperative and will to make children continue fishing can be negatively related to the decision to diversify into other professions.

2.2. Empirical assessment of drivers of adaptation

2.2.1. Data collection and survey sites

Structured household surveys were conducted to collect the required information on implementation of adaptation strategies and its drivers (Table 1) in the communities. Observations from focus group discussions as well as suggestions from experts (marine fishing and social scientists) helped in refining the questionnaire before proceeding for the survey. A pilot survey with 50 households in the area was also done before finalizing the questionnaire.

The sites of interest for this study are fishing villages located in urban, semi-urban and rural areas. Hence, stratified random sampling is adopted to select the survey households. Urban fishing communities are selected from Mumbai, which is one of the largest cities in Maharashtra as well as in India. A total of six fishing settlements, namely, Mahim, Versova, Khar Danda, Colaba, Cuffe Parade and Worli, are selected from Mumbai. Four fishing regions around Mumbai, namely, Ulwe, Diwale, Vasai and Alibag are considered to understand semi-urban communities. Revdanda, Murud, Rajpuri, Pajpandhari and Harnai are the five rural fishing villages included in the study. Fig. 1 shows the location of the survey sites.

200 households each from urban and rural, and 201 from semi-urban region were surveyed, resulting in a total of 601 responses. The sample exclusively consists of fishermen who owns a boat and physically goes into the sea to fish. The heads of the households, who are the most active in fishing, were interviewed. The entire field work was conducted in between April 2016–January 2017.

2.2.2. Statistical analysis

The statistical significance of the influence of drivers on adaptation responses (as hypothesized in Table 1) is examined through logistic regression. Multinomial logistic regression is used to assess the association of variables (Table 1) with the adoption of motorized and mechanized boats in the community. The dependent variable is boat type, where 0 indicates ownership of non-motorized boat, 1 is equivalent to having a motorized boat and 3 indicates having a mechanized boat. Binary logistic regression is used to examine the drivers (Table 1) of each of the other adaptation responses, that is, use of multiple types of nets, working longer hours, fishing farther, having boat insurance and household diversification. Here, the dependent variable takes a value of 1 if the respondent has taken up the adaptation strategy and 0 if otherwise. The explanatory variables are a mix of binary and continuous (Table 1). A binary logistic regression model depicts the relationship between the log of the odds ratio and the explanatory variables (Eq. 1). Odds ratio is the ratio of the probability of an event taking place to the probability of the event not taking place.

$$\ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \ldots\ldots + \beta_k X_k \quad (1)$$

where P_i is the probability of an event taking place (i.e. deciding to adapt in this study) and X are the explanatory variables.

Thus, the coefficients of a logistic regression indicate change in log of odds ratio and are difficult to interpret directly. They give just an indication of the probability of the occurrence of the phenomenon relative to their respective explanatory variable. On the other hand, marginal effect which can be computed from logistic regression reflects difference in probability when independent binary variables change from 0 to 1 (Eq. 2) or for unit change in categorical/continuous variables (Eq. 3) (Williams, 2016). Their magnitudes are easier to interpret and are more meaningful (Cameron and Trivedi, 2009). Thus, the marginal effects are estimated for each regression equation.

$$\text{Marginal effect of } X = P(P_i = 1|X_k = 1) - P(P_i = 1|X_k = 0) \quad (2)$$

$$\text{Marginal effect of } X = P(P_i = 1|X_k = n+1) - P(P_i = 1|X_k = n) \quad (3)$$

Before building the regression models, the variables are checked for correlation among them. All independent variables, with correlation greater than 0.5, are dropped. This resulted in dropping of the variable "trust and cooperation with authority" for the urban community as it is correlated with "community cohesion". Further, the variable indicating presence of relatives in fishing is dropped for the semi-urban and rural fisherfolk as 99.5% of them have fishing relatives. Similarly, 99.5% rural respondents have cooperative membership, hence it is dropped for the rural regressions. The significance of the final models is concluded using Hosmer-Lemeshow test (Brief explanation in Appendix C of supplementary material).

3. Results and discussion

3.1. Adaptation in the communities

The percentages of respondents adopting different strategies in the three regions are depicted in Fig. 2. In the urban community, a high percentage (77.5%) of fishermen have adopted the most advanced boat type, that is, mechanized boats. Non-motorized and motorized boats

Table 1
Explanatory variables and their description.

S·No.	Type	Explanatory Variable	Hypothesis about influence on adaptation	Description	Remarks based on FGDs and literature	Reference
1.	Human capital	Level of education	+	Categorical ranging from being illiterate (=1) to post-graduate (=11)[a]	Education can provide better access to information about new fishing technologies, weather forecasts, availability of loans and networks.	Islam et al. (2014a, 2014b), Metcalf et al. (2015), Pauly (2005), Senapati and Gupta (2017)
2.		Experience in fishing	+	Continuous	Experience can lead to better knowledge about the profession which can consequently help in choosing appropriate adaption options. It can also build perception about changes in the ecosystem, climate, market etc.	Allison et al. (2005), Islam et al. (2014a, 2014b), Metcalf et al. (2015)
3.	Economic capital	Formal source of credit[a]	+	Binary Available = 1 Otherwise = 0	Sources of economic capital can contribute to investing in better/more boats, gear, helpers etc.	Deressa et al. (2009), Hisali et al. (2011), Islam et al. (2014a, 2014b), Metcalf et al. (2015), Senapati and Gupta (2017), Uddin et al. (2014)
4.		Informal source of credit[a]	+	Binary Available = 1 Otherwise = 0		
5.		Access to subsidy (on fishing materials/gear, diesel)	+	Binary Available = 1 Otherwise = 0		
6		Asset index	+	Continuous Computed by taking weighted (generated using Principal Component Analysis) sum of 16 household assets (Jain et al., 2015)[a]		
7.	Social capital	Number of household members who fish together	+	Continuous	Involvement of household members implies considerable dependence on fishing as a livelihood for the family. This might initiate them to adapt. Also, more physical and financial help might be possible through household participation, which can consequently enable them to explore various adaptation options.	Blythe et al. (2014), Divakarannair (2007), Islam et al. (2014a, 2014b), Metcalf et al. (2015), Sievanen (2014)
8.		Number of household members who stay back	+	Continuous	Presence of adult household members, who can stay back during fishing trips, is important for taking care of the household.	
9.		Relatives in fishing	+	Binary If present = 1 Otherwise = 0	These factors indicating social capital can help in forming fishing groups, taking care of family in absence of family head, lead to better information dissemination and provide avenues of help during lean period. Networks with authority can provide better access to information, loans and finances.	
10.		Number of close friends	+	Continuous		
11.		Community cohesion (Trust and cooperation among the community)	+	This is an indicator for bonding social capital. Computed by taking average of Likert scale values of five items indicating trust and cooperation among the community members (Cinner et al., 2015)[a]		
12.		Trust and cooperation with authority	+	This is an indicator for linking social capital. Computed by taking average of Likert scale values of five/four items indicating trust and cooperation with authorities such as fishing society, local government and other agencies (Cinner et al., 2015)[a]		
13.		Membership in fishing cooperative society	+	Binary If has membership = 1 Otherwise = 0		
14.	Perceptual factors	Perception of increased trade competition	+	Binary If competition perceived = 1 Otherwise = 0	Perceptual factors help judge the current and future scenarios. This assists in taking necessary precautions and planning livelihoods accordingly.	Adger et al. (2009), Comoé and Siegrist (2013),Jain et al. (2015)
15.		Perception of change in climate affecting fish population	+	Binary If change perceived = 1 Otherwise = 0		
16.		Perception of increase in extreme events (such as storms and cyclones in the sea)	+	Binary If increased frequency perceived = 1 Otherwise = 0		
17.		Perception of	+	Binary		

Table 1 (*continued*)

S·No.	Type	Explanatory Variable	Hypothesis about influence on adaptation	Description	Remarks based on FGDs and literature	Reference
		increase in pollution		If pollution perceived = 1 Otherwise = 0		
18.		Will to make children continue fishing (form of cultural capital)	+	Binary Want children to fish = 1 Otherwise = 0	Fisherfolk, involved in fishing since generations, strongly consider fishing as part of their cultural identity and generally do not want to leave their profession. Thus, future plans of fishing as a livelihood for their children might initiate adaptation.	Daw et al. (2012), Pollnac and Poggie (2008)

[a] Details in Appendix A.

are low in number and have almost equal shares. In the semi-urban areas, the community is majorly using motorized boats (83.1%), but has been unable to adopt mechanization (only 1.5%). The rural community has the least percentage of non-motorized boats (3.5%) and is majorly using motorized (64%) and mechanized (32.5%) boats. Thus, overall mechanization is predominant in the urban region whereas motorization is most adopted in the semi-urban and rural region. Among the three communities, the presence of non-motorized boats is the least in rural (3.5%), suggesting that most of the community is using advanced boats. This has also resulted in the exclusion of non-motorization as a category of boat type while running logistic regression for the rural community in Section 3.2.3. This is necessary to obtain reliable output from regression analysis. Similarly, mechanization is the least (1.5%) in the semi-urban region. Hence, only the determinants of motorization could be estimated for the semi-urban fishermen (in Section 3.2.2).

Usage of multiple types of nets is the most popular adaptation strategy to improve fish catch in the three communities. 89.5% and 87.5% of the urban and rural community respectively have multiple types of nets (Fig. 2). The semi-urban community is a little behind as only 78.1% of them have adopted this strategy. Again, much of the semi-urban community has not increased their working hours or distance compared to the urban and rural communities. The rural fishermen lead in insuring their boats (88.5%), followed by the urban (84.5%) and semi-urban (76.1%) respondents. Overall, the semi-urban community appears to differ and has the poorest percentage adoption of strategies among the three regions. This difference can be explained by the fact that communities have varying access and association with drivers that lead to adaptation (described in the next Section 3.2).

Few (11%) fishing households in the urban region have been able to diversify their income (Fig. 2), indicating that diversification opportunities are greater in urban areas. Thus, factors influencing household diversification in only the urban community could be studied.

In the following analysis, any strategy which has an adoption percentage of lower than 10%, or the ratio of respondents not adopting the strategy to those who have is greater (or equal) than 20 (Kuhn and Johnson, 2013), has not been considered for the respective communities.

3.2. Regression results

The descriptive statistics of the hypothesized drivers of adaptation (Table B.1, B.2 and B.3 of Appendix B in supplementary material) show that the three groups have varying level of availability/access to many of them. For example, while almost all the semi-urban and rural respondents have relatives engaged in fishing, the urban community has 80% fishing relatives. The urban community has a very high average asset index (0.77) compared to the semi-urban (−1.29) and rural (−1.39) communities. Again, the rural community (89%) has higher access to subsidies than the urban (71.5%) and semi-urban (62.2%) communities. The characteristics of the three communities seem to differ and hence, each group demands independent investigation.

The following sub-sections discuss the statistical association between drivers and adaptation strategies in urban, semi-urban and

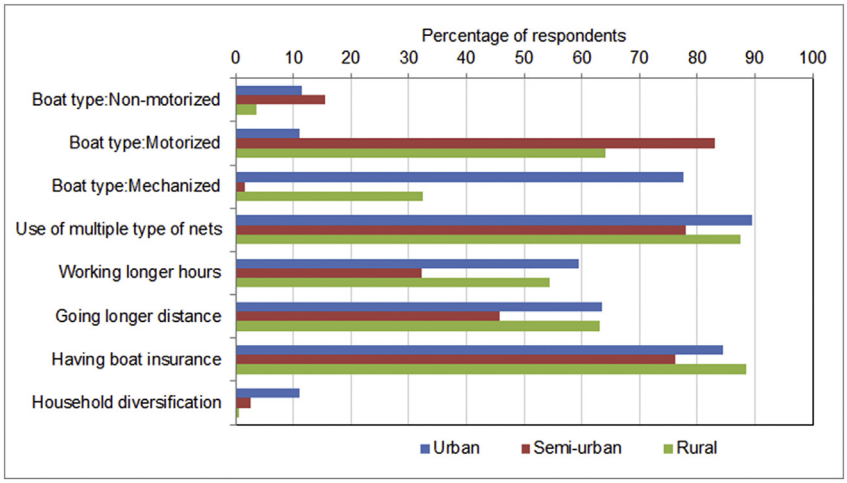

Fig. 2. Percentage of fishermen undertaking each adaptation strategy in the three communities.

rural areas separately. The marginal effects of the regression models are listed in Tables 2, 3 and 4 for urban, semi-urban and rural regions respectively. The coefficients of the models are presented in Appendix C (Table C.1, C.2 and C.3) of supplementary material.

3.2.1. Urban community

Economic capital seems to be an important factor for adoption of motorization and mechanization among fishermen in the urban region (Table 2). While only subsidies, which are provided by cooperative societies, enable motorization, formal sources of credits are also significant for mechanizing boats. Presence of household assets can also contribute to economic capital and enable mechanization. Among the sources of economic capital, subsidies have the highest marginal effect on the decision to mechanize followed by assets and formal credits. A higher level of education can also help to adopt mechanization. Perception of impact of climate change on fish population is an important driver of mechanization as well. But it is seen that fishermen who perceive decline of extreme events in the sea have only limited their adaptation to motorization, which are lighter and less tolerant to strong winds in the sea compared to mechanized boats.

Availability of both formal and informal credits is associated with use of multiple net types. Both these sources of credit have marginal effects of 0.159 and 0.114 respectively. But a lower asset index is related to having multiple nets. This might suggest that economically weaker fishermen in the urban community are adopting use of multiple nets, and they rely considerably on credits for investing in nets.

It was hypothesized (Table 1) that more number of household members available to take care of families can enable adaptation among fishermen, as this would relieve them of household responsibilities. But this variable is negatively associated with usage of multiple net types, working longer hours and going longer distance in the urban community (Table 2). However, the marginal effect of number of household members fishing together, although not significant, is positive. This reflects that most family members of fishermen, who have adopted these strategies, fish together and there are not many members left behind in the household. Further, having more number of close friends enable fishermen to have multiple nets and work longer hours.

Fishermen who perceive increased competition and pollution are more likely to adopt multiple nets and insure their boats. Perception of competition has slightly larger marginal effect than pollution. It was understood from the focus group discussions and survey that multiple types of nets allow different varieties in fish catch, which enable fishermen to compete their sales with other fishing boats. Again, since nets get easily damaged due to increasing debris and pollution in the sea, having multiple nets can be beneficial. However, fishermen using multiple nets and having insurance perceive a decline in extreme events. Fishermen recognize trade competition and pollution to be more consequential for their livelihoods (as noted from their positive association with adaptation strategies), than extreme events. As most boats in the community are mechanized (75%), which are less vulnerable to extreme weather events (such as strong winds and cyclones) compared to lighter motorized boats, a negative relation between boat insurance and perception of extreme events might also be a result of reassurance among fishermen about their safety. Urban fishermen having boat insurance might perceive greater safety in the sea and lower impact of extreme events. However, the ability to insure boats is also influenced by higher levels of education, availability of formal credits and subsidies. The marginal effects show that subsidies are the most crucial for having boats insured. This suggests that, rather than perceived risk from extreme events, access to the other significant capitals is crucial for having boat insurance.

Fishermen who are older and those who have poor education are more likely to work longer. Among these two sources of human capital, education has a negative and higher marginal effect. This indicates that higher educated fishermen choose not to toil and work longer. Respondents who work for longer hours and travel greater distance also do not want their children to continue fishing. They want their younger generations to move to more remunerative and comfortable sources of livelihood.

Fishermen who are opting to travel longer distances do not have access to formal credits. On the other hand, fishermen having mechanized boats are driven by formal credits. This suggests that fishermen having the other boat types (especially non-motorized), whose adoption is not influenced by formal credits, are relatively putting in more effort and opting to travel farther than earlier.

Fishermen whose households have diversified sources of livelihood have relatives in fishing. Thus, traditional fishing families, who have varied fishing experiences and perhaps perceive a gloomy future of the fishing sector, are choosing to diversify. However, they also do not perceive adverse impact of climate change on fish catch. This shows that respondents whose households have diversified and those who have intensified, through mechanization, have contrasting perceptions. One reason for this difference might be that households having other source of income are comparatively less involved and do not rely much on fishing, leading to less vigilance about long-term climatic stresses.

Table 2
Marginal effects of drivers in urban community.

		Boat type: motorized	Boat type: mechanized	Use of multiple type of nets	Working longer hours	Going longer distance	Having boat insurance	Household diversification
Human capital	Level of education	0.009	0.029*	0.005	−0.046**	0.004	0.026*	0.023
	Experience in fishing	0.002	−0.001	0.000	0.006*	0.005	0.001	0.002
Economic capital	Formal source of credit	0.021	0.097*	0.159**	−0.047	−0.140*	0.099*	−0.043
	Informal source of credit	−0.008	−0.032	0.114*	0.006	−0.015	−0.115	−0.022
	Subsidy	0.066***	0.243***	−0.008	−0.125	−0.085	0.173***	−0.057
	Asset index	0.050	0.166**	−0.156***	−0.002	−0.038	0.026	0.072
Social capital	Household members who fish together	0.030	0.001	0.017	0.062	0.016	−0.027	−0.001
	Household members who stay back	0.016	0.017	−0.025*	−0.058*	−0.099***	0.039	0.018
	Relatives in fishing	0.022	−0.006	−0.019	−0.035	−0.009	0.069	0.153*
	Close friends	0.000	0.000	0.005*	0.007*	0.005	−0.002	0.003
	Community cohesion	−0.063	0.051	−0.033	0.040	−0.018	0.022	−0.041
	Membership in cooperative society	0.033	−0.103	0.079	0.082	−0.022	0.114	−0.113
Perceptual factors	Increase in competition	−0.034	0.041	0.107**	−0.043	0.111	0.138**	0.116
	Climate change affecting fish catch	−0.039	0.156*	0.003	0.065	0.088	0.083	−0.155**
	Increase of extreme events	−0.095*	0.056	−0.090**	0.011	0.008	−0.075*	0.030
	Increase in pollution	−0.012	0.005	0.088	−0.077	−0.214	0.115*	0.113
	Will to make children continue fishing	0.012	0.063	0.035	−0.168**	−0.127*	0.061	0.009
Pseudo R^2		0.544		0.464	0.203	0.181	0.487	0.272

* Significant at 90% confidence level.
** Significant at 95% confidence level.
*** Significant at 99% confidence level.

Table 3
Marginal effects of drivers in semi-urban community.

		Boat type: motorized	Use of multiple type of nets	Working longer hours	Going longer distance	Having boat insurance
Human capital	Level of education	0.032**	0.021	−0.008	−0.004	0.013
	Experience in fishing	0.002	0.009**	−0.002	−0.003	−0.001
Economic capital	Formal source of credit	−0.054	−0.074	0.077	0.062	0.083
	Informal source of credit	0.180***	0.131**	0.046	0.165**	0.040
	Subsidy	0.193***	0.005	−0.131	0.117	0.128**
	Asset index	0.041	0.137**	−0.025	−0.084*	−0.012
Social capital	Household members who fish together	0.036	−0.055	−0.072	−0.134***	0.130**
	Household members who stay back	0.085	0.050	0.177**	0.073	−0.009
	Close friends	0.001	0.003	−0.005	0.002	0.002
	Community cohesion	−0.072	0.052	0.013	−0.051	−0.074
	Trust and cooperation with authority	0.039	0.168***	−0.001	−0.059	0.048
	Membership in cooperative society	0.144**	0.024	0.263**	0.382***	0.205***
Perceptual factors	Increase in competition	0.220	0.169	−0.083	−0.231	0.095
	Climate change affecting fish catch	−0.068	0.033	−0.013	0.046	−0.192
	Increase of extreme events	0.098*	−0.078	0.067	−0.129*	0.114*
	Increase in pollution	0.230*	−0.141	0.192	−0.037	0.326**
	Will to make children continue fishing	−0.009	−0.078	−0.010	−0.002	0.022
Pseudo R^2		0.581	0.389	0.241	0.347	0.521

* Significant at 90% confidence level.
** Significant at 95% confidence level.
*** Significant at 99% confidence level.

All the regression models are significant and explain variance ranging from 18.1%–54.4% in adaptation decisions in the urban fishing community (Table 2).

3.2.2. Semi-urban community

Having higher levels of education, access to informal credits, subsidies, cooperative membership, perceiving increased frequency of extreme events and pollution increases the likelihood of motorization (Table 3). Marginal effects show that perception of pollution has the highest contribution to the decision to motorize, followed by economic capital and membership in cooperative. Use of multiple types of nets is associated with experience in fishing, presence of informal credits, assets and trust and cooperation with authority. Working for longer number of hours is associated with number of household members who can stay back and membership in cooperative. Insuring one's boat is influenced by having access to subsidy, household members who go for fishing together, membership in cooperative, perception of increased extreme events and pollution. Thus, the hypotheses (Table 1) regarding the relation between the various drivers and these four adaptation strategies are accepted for the semi-urban community.

Travelling farther in the sea is initiated by informal credits and cooperative membership (Table 3). This leads to acceptance of the hypotheses (Table 1). But travelling greater distance is negatively associated with asset index, number of household fishing partners and perception of increase in extreme events. Distance being negatively related to assets signifies that poorer households are adopting this strategy. Further, it appears that fishermen do not prefer to go long distance with family members. This is because most boats in the community are motorized. Since these boats are smaller and have fewer facilities for long-term habitation, such as space for food supplies, sleeping etc., compared to mechanized boats, greater number of people cannot be accommodated for longer distances. It is interesting to note that respondents having motorized boats perceive increase in extreme events but fishermen going longer distances do not. Thus, although fishermen might be having motorized boats, only those who believe the sea to be calm and safe are choosing to go farther.

Table 4
Marginal effects of drivers in rural community.

		Boat type: Mechanized	Use of multiple type of nets	Working longer hours	Going longer distance	Having boat insurance
Human capital	Level of education	−0.004	−0.001	0.009	−0.015	0.000
	Experience in fishing	0.002	0.000	0.009*	0.003	0.000
Economic capital	Formal source of credit	0.020	−0.008	0.115	−0.203**	0.029**
	Informal source of credit	−0.061	0.000	0.134	0.014	0.001
	Subsidy	0.247	0.001	0.251*	0.329**	0.172***
	Asset index	0.041	−0.004	0.086	−0.033	0.001
Social capital	Household members who fish together	−0.083**	−0.003*	−0.116**	−0.109**	0.003
	Household members who stay back	−0.047	0.002	−0.035	0.035	0.004
	Close friends	0.007***	0.002**	−0.005	0.001	0.000
	Community cohesion	0.165***	−0.004	0.030	0.154*	0.003
	Trust and cooperation with authority	−0.035	−0.002	−0.218**	−0.141**	−0.001
Perceptual factors	Increase in competition	0.307	−0.007	0.427	0.362	−0.110
	Climate change affecting fish catch	0.180	0.018	0.068	−0.203	−0.017
	Increase of extreme events	0.083**	−0.004	0.202**	0.162**	0.009
	Increase in pollution	−0.021	−0.006	0.164	0.242	−0.008
	Will to make children continue fishing	0.078	0.003	0.087	0.104	0.001
Pseudo R^2		0.308	0.401	0.211	0.173	0.329

* Significant at 90% confidence level.
** Significant at 95% confidence level.
*** Significant at 99% confidence level.

The regression models for the semi-urban community significantly explain variance ranging from 24.1%–58.1% in the decision to adapt (Table 3).

3.2.3. Rural community

Mechanization of boat in the rural region is not related to any aspect of economic capital (Table 4). However, it is strongly influenced by social capital, such as number of close friends and community cohesion. Community cohesion has the highest marginal effect. Again, it appears that fishermen do not go with household members for fishing, indicated by a negative association with the variable. This might signify that they are choosing to fish with the rest of the community over household members. The group discussion also divulged that families often get into dispute over ownership of gear, and hence prefer to fish separately. Similarly, using multiple net types is positively related to having number of close friends. But number of household members who fish together is negatively influencing adoption of multiple nets. This variable is also negatively linked to the other adaptation strategies of working longer and going greater distances. Further, travelling distances to fish is positively related to community cohesion. Thus, overall social capital is a contribution from friends and community in the region rather than family members.

Respondents who have adapted by working longer and going farther have low trust and cooperation with authority (Table 4). This indicates that the community does not perceive authorities to be helpful towards them.

Fishermen who have mechanized, work longer and go farther perceive increasing number of extreme events (Table 4). Perception of extreme events is positively related but does not significantly influence uptake of boat insurance (as hypothesized in Table 1). Access to economic capital in the form of formal credits and subsidies appear to be more important for having insurance, than perceived risk. Subsidies have the highest marginal effect on insuring boats. Marginal effects also show that access to subsidies can majorly determine the choice to work longer and fish farther in the sea. But members of the community who are going more distances than earlier do not have access to formal credits, as indicated by a significant negative coefficient between the two. This reflects lack of formal financial support, which might have also led to poor trust and cooperation with authority.

Further, fishermen fishing for a number of years are more likely to work longer (Table 4). This shows that experienced fishermen have changed their fishing habits over the years.

Variances of 17.3%–40.1% are significantly captured by the regression models for the rural region (Table 4).

3.3. Adaptation drivers in the communities and implications

Based on the regression results in Section 3.2, the following compares and discusses the drivers of adaptation behavior in the three regional communities. Some implications of the empirical results and insights from the FGDs are also presented. Further in Table 5, the study identifies some necessary interventions by different tiers of stakeholders for capacity-building of the community. Table C.4 in Appendix C (of supplementary material) compares and gives an overview of the accepted hypotheses in the three communities.

3.3.1. Stresses driving adaptation

The link between perception of frequency of extreme events and adaptation varies among the three communities. The semi-urban community has adopted motorization and boat insurance as they perceive increasing strong winds in the sea. Rural mechanized fishermen as well as those who work longer and travel farther perceive increasing extreme events. There is scientific evidence that tropical storms/cyclones have been increasing over the Arabian Sea (Dash et al., 2007; Wang et al., 2012). On the contrary, a lowering perception of extreme events is related to motorization, use of multiple nets and having boat insurance in the urban community. This is a deviation from the proposed hypothesis (Table 1). Similar results were also obtained by Tucker et al. (2010) where perception of risk was negatively impacting adaptation among farmers, indicating other factors/capitals to be more dictating than perceived risk. Likewise, in this study, economic capital such as formal credits and subsidies seem to be more important for having boat insurance. Such results also suggest that experiences of impacts

Table 5
Practices/interventions necessary for capacity-building of the community by different tiers of stakeholders.

Stakeholder/actor	Practices/interventions needed
State and national government	• Deploy local authorities to strictly implement existing policies on pollution control. • Redesign and improve permeation of existing programmes on access to cooperatives, provision of subsidies on fishing gear/materials, life and property insurance. • Design special credit schemes (in nationalized/-cooperative banks) for traditional fishing communities, with liberal eligibility conditions and requirements of collateral assets. Also, improve accessibility of credits from NCDC by making the application process punctual and easier for fishermen having varying levels of education. • Design policies to protect traditional fishing livelihoods along with the marine ecosystem from commercial and destructive forms of fishing. There are provisions for the same in the Comprehensive Marine Fishing Policy 2004 (Government of India, 2004), but states need to give effective guidelines for their implementation. • Provide reliable weather information systems specifically designed and reachable to fishermen moving across vast expanses of the sea. Although there have been instances of providing weather information electronically (sourced from INCOIS- Indian National Centre for Ocean Informative Services), the community is not satisfied with their accessibility and reliability. Hence, necessary improvements need to be made. • Design awareness programmes for associated government authorities and community regarding the impact of climate change on fishing livelihoods. • While there are a number of agriculture related adaptation projects under the National Adaptation Fund on Climate Change (NAFCC), there are only a few on coastal livelihoods (MoEF and CC, 2014; NABARD, 2015). Thus, more investment in research and development activities to adapt fishing livelihoods to changes in oceanography and climate is required. • Involve stakeholders from the community in all policy/-decision-making processes.
Local government	• Strictly implement existing policies on pollution control. • Implement other policies and programmes related to provision of subsidies, insurance, weather warnings, protecting traditional livelihoods and awareness generation (about climate change impacts). • Identify and initiate establishment of cooperatives in villages not having their access. • Identify villages lacking in fishing-related public infrastructure (e.g. jetty/pier, roads and electricity at harbor) and provide the necessary assistance. • Develop relations of trust and cooperation with the community. Coordinate with community and fisheries society to understand gaps in policy implementation and communicate the same to higher tiers of government.
Community and fishing society	• Ensure inclusion of all fishing households of the village in their cooperative society. And provide easy and unbiased access to subsidies, credits and insurance. • Harness community cohesion to cooperatively manage and sustain the marine ecosystem. • Actively participate and communicate their livelihood concerns, such as those related to provision of subsidy and fishing-related public infrastructure, with local authorities. • Motivate each other to provide formal higher education to their next generation.

of extreme events among urban fishermen are different from the other two communities. A plausible reason might be that urban fishermen who have adopted mechanized boats (which is the major boat type) and insurance are less perturbed by anticipated impacts of such events leading to a perception of declining extreme events. Also, fishermen having motorized boats might not be going deep enough into the sea to experience such events. Hence, their perception differs; and adaptation among urban fishermen is not positively linked to extreme weather events in the sea and is driven by other stresses. Nevertheless, in view of increasing frequency of storms and cyclones, reliable weather warning systems are required for the community.

Unlike semi-urban and rural fishermen, perception of adverse impact of climate change on fish catch drives mechanization in the urban region. The urban community exhibited their high awareness about changes in climate, and its repercussions on fish spawning and distribution through the group discussions. Such practical awareness about climate change could not be observed among semi-urban and rural fishermen. Programmes to educate and generate awareness about adverse impacts of climate change on ocean biodiversity among the communities can be beneficial. This might help them to anticipate any changes in their livelihood and make appropriate individual/community adaptation plans.

In urban and semi-urban areas, increasing pollution impacts decisions to adapt strategies such as motorization and use of multiple types of nets. Although there are regulations to control pollution (MoEFCC Govt. of India, 2011), they have not been implemented well and widespread pollution still persist (Bharucha, 2017; Chatterjee, 2016; Porecha, 2015). There is dire need of strict policy actions to control pollution to sustain the coastal ecosystem as well as the livelihoods of traditional fishermen.

Trade competition in the urban region is associated with adoption of multiple types of nets. This calls for appropriate management of the fishing industry to sustain traditional livelihoods as well as to avoid overfishing. Members of the urban community opined during the group discussion that authorities should regulate the number and type of boats that a fisherman can own, so that the extraction of marine resources remains sustainable. There should also be restrictions on using small-sized mesh and trawl nets which impact fish population and are detrimental to the ecosystem.

Hence, climatic stresses such as extreme events drive adaptation in semi-urban and rural communities. Additionally, adaptation in the semi-urban community is influenced by environmental pollution. In case of the urban region, perception of adverse impacts of climate change on fishing as well as other human induced stresses such as competition and environmental pollution are linked to adaptation.

3.3.2. Influence of human capital

Education can improve access to information on technology, credit and other government schemes. Thus, education is seen to be an important determinant for adopting mechanization and motorization in urban and semi-urban region. Education is also important for having boat insurance among urban fishermen. But education is not related to uptake of mechanized boat among rural fisherfolk. Overall, the rural community is quite different from the other two in terms of the factors that are relevant to the decision to adopt advanced boats. The rural community is more influenced by social capital rather than human and economic capital.

Although working longer hours is a form of adaptation, it makes fishermen toil and keeps them away from their family. Hence, it is not the most comfortable adaptation strategy. It is seen that fishermen with low education prefer this strategy in urban areas, whereas respondents with higher education opt for mechanized boat and insurance. Educated semi-urban fishermen also prefer to motorize boats. Thus, it can be inferred that education is crucial for enabling fishermen to adopt better and appropriate forms of adaptation.

Again, it is observed that older fishermen, in urban and rural region, having long experience in the profession are changing their practices and working for greater number of hours. This reflects that there have been major changes in fish catch over the years. Fishermen who have been observing the sea for a number of years are thus seen to have significantly increased their working hours. Experienced fishermen in semi-urban region are also using multiple types of nets. Such experienced fishermen can share their perceptions through stakeholder engagements and make meaningful contribution to research on understanding changes in ocean biodiversity and extreme events.

3.3.3. Economic capital is crucial

Access to subsidies is a very important factor to initiate adaptation among all the three groups. Further, formal credits from banks and government sources, such as National Cooperative Development Corporation (NCDC), influence boat type as well as boat insurance. Formal credits also help in having nets in the urban region. The communities often have difficulty in acquiring formal credits from nationalized banks as collateral assets such as land and gold are required for loan applications. This has also led to a lower marginal effect of formal credits than subsidies in urban region. Thus, institutional financial support through specialized credit schemes and subsidies can build adaptive capacity of communities. Informal credits come into play for less financially intensive adaptation through motorization and using multiple nets.

3.3.4. More relevance of social capital in rural community

Owning a mechanized boat require greater finances than a motorized boat. Hence, it is observed that formal credits and assets, which can be used to borrow large economic resources, contribute to mechanization in the urban region. Motorization is significantly linked to solely subsidies in the urban area. Similarly, the semi-urban community depends on smaller funds from informal credits and subsidies for motorization. Hence, economic capital is an important driver of adopting motorized and mechanized boats. This hypothesis is accepted in case of the urban and semi-urban communities. But having a mechanized boat, which can be financially intensive, is not linked to economic capital in the rural region (Table 4). Social networks (such as friends and community), which can serve as source of information, support and help, are extremely important for adaptation among the rural community (Table 4). On the other hand, none of the variables of social capital are related to having an advanced boat among the urban fishing community (Table 2). In case of semi-urban fishermen, membership in cooperative, a formal means of social capital, is significant to own a motorized boat (Table 3). This illustrates that the rural community is particularly close knit and cooperates with each other in need. Further, it might be said that the rural community has comparatively better inherent adaptive capacity.

Policy planners can take advantage of this cooperative spirit among the group while designing, coordinating and implementing community adaptation schemes and ecosystem management strategies. The literature (Grant, 2001; Kusakabe, 2013) also indicates that strong social networks among community members can help in smooth and successful implementation of development programmes. Social networks can assist community members and leaders, coordinating such programmes with local authorities, to motivate other members to actively participate. It is observed through the FGDs that fishermen often share information regarding fishing zones and available credits among themselves. They spend most of their days in the sea with fellow fishermen and prefer to unwind with their family/community when on a break from fishing. Thus, fishermen appear to have strong bonding social capital which can be used to effectively implement collaborative adaptation management strategies.

3.3.5. Role of cooperatives

The coefficients (Table C.2 in supplementary material) and marginal effects (Table 3) for the semi-urban regression models show that

cooperative membership is vital for adaptation. The semi-urban community has the lowest cooperative membership among the three groups (Table B.2 in Appendix B of supplementary material). Hence, its statistical significance provides evidence that such memberships can indeed capacitate community members to adapt. Cooperatives are generally the nodal agencies responsible for distributing government subsidies. It is seen that the semi-urban community, which has the least cooperative membership, also has low access to formal credits and subsidies. Thus, policies that trickle down cooperative and extension services to every member of the community can substantially help underprivileged fisherfolk. The state and local government need to identify fishing communities not having access to cooperatives in their own or nearby village. Further, necessary bureaucratic and financial assistance should be provided for their establishment.

3.3.6. Trust and cooperation with authority

The average indices for trust and cooperation with authority (which is a form of linking social capital) for all three communities are negative (Table B.3 in Appendix B of supplementary material). The urban and semi-urban fisherfolk have an average trust and cooperation measure of −0.04 and − 0.44 respectively. The rural community has the lowest average (−0.80) trust and cooperation with authority. This reflects that most members of all the three communities severely distrust institutional authorities. While this factor is positively related with use of multiple types of nets in semi-urban region, it negatively impacts working longer and going farther in rural region. This shows that the semi-urban community perceives that they are supported by authorities in a few ways. But the rural community, who has had to change their fishing practices and work harder, has completely given up its expectations from authorities. As noted from group discussions, such beliefs might be because of favoritism towards sections of the community and difficulties faced (such as time-consuming and complex procedures) during acquisition of limited institutional benefits/formal credits. Also, the communities perceive that the government disregards them, especially compared to traditional farming communities. While there are a number of interventions for the agricultural sector in India, marine fishing has not been much focused upon. Further, the communities voiced that the state has been prioritizing polluting industries over sustainability of the marine ecosystem. There have not been suitable measures to control ocean pollution, which is one of the major stresses affecting their livelihoods. Policy attention as well as serious implementation is required for gaining the faith of these communities. Relationship of trust between authorities and community can be improved solely by designing and implementing interventions supporting fishing livelihoods (Table 5) by the different tiers of government. This includes policies on control of pollution, destructive fishing methods, availability of credits/subsidies and fishery related public infrastructure. Additionally, these interventions need to be designed in coordination and approval from the community. This can substantially help to restore trust of the community on the government.

The FGDs and household survey also indicated that communities in many of the study sites do not have any political representation in their respective areas. They would like to be politically active in hopes of having greater policy support and improving their overall socio-economic condition. They also feel that only a fisherman would be able to understand and design policies pertaining to their livelihoods as fishing is a highly specialized activity. But, hectic fishing schedules (because of which they are mostly away from land) and lack of opportunities prevent them from having active participation in the political scenario (or forming pressure groups) of their areas. However, such representation of the community, especially in the local tiers of the government, may significantly improve their trust on authorities.

3.3.7. Cultural identity and planning for future generations

Urban traditional fishermen who have started working longer and going farther in the sea do not want their children to continue fishing. Also, unlike the semi-urban and rural community, few urban fishing households have diversified their livelihoods. Members of such families are contributing to the household income by running small business, working in offices or driving taxis/rickshaws in Mumbai city. This shows that the urban community has greater awareness and access to diversification opportunities.

Fishermen generally identify their livelihood as part of their culture which makes them reluctant to leave fishing (Pollnac and Poggie, 2008). Strong cultural identification could be observed among the semi-urban and rural fishermen. Many of the surveyed rural areas have a thriving beach tourism industry which can be a source of livelihood diversification. But none of the surveyed fishermen are involved in any of the tourism business. The group discussions revealed that the semi-urban and rural communities have no skill other than fishing. They spend most of the days in the sea and want to spend their limited time on land with their families. The fisherfolk are not much interested to interact with people outside their community and prefer not to diversify. However, most of them want their children to pursue other professions (Table B.2).

4. Conclusion

Recognizing the drivers of adaptation decisions can be immensely helpful to comprehend community dynamics and plan interventions. This study presents a framework to examine the factors associated with adaptation decisions in marine fishing communities. The framework integrates different aspects of human, economic, social and perceptual factors that might influence adaptation responses. Drivers may be intrinsic, such as social capital, or extrinsic, such as availability of subsidies, to the community. The study highlights that some drivers of adaptation can be same and some may significantly vary among urban, semi-urban and rural communities. For example, while social capital (particularly, community cohesion and close friends) is a major driver among rural fishermen, the same is relatively less relevant for urban and semi-urban fisherfolk. It is concluded that economic capital, especially subsidies, and institutional support through cooperatives are critical for adaptation across communities. Education may enable making appropriate adaptation choices, such as using an advanced boat and insuring it. The communities' adaptation decisions have assorted relation with perception of stresses. Interestingly, adaptation responses (mechanization) in the urban region are driven by impact of climate change on fish population but are linked to lowering perception of extreme events. Experienced fishermen are more likely to increase their number of working hours to adapt to the drastic changes in fish catch over the years. The communities have poor trust on authorities; and require appropriate policy interventions to build adaptive capacity and simultaneously maintain the marine ecosystem. Further, urban fishermen who have intensified by working longer and fishing farther do not want their future generations to be in fishing. Unlike semi-urban and rural communities, few urban households have diversified and have developed alternate livelihood skills.

It is observed that the communities have varied availability/levels of capitals and perceptions (Descriptive statistics in Appendix B of supplementary material). This calls for different intensity of policy implementation in the regions. For example, since cooperative membership is important for adaptation and the semi-urban community is low on it, there is an urgent need for cooperatives to support them. However, the three communities have similar short-falls in case of few capitals. For example, policy measures on improving outreach of education and formal credits are needed for all the three communities. Further, the results imply that different implementation design based on regions might be helpful. For example, social capital being more relevant for the rural community, relationships of trust and cooperation among its members (community cohesion) might be harnessed for effective implementation of adaptation/ecosystem management plans.

The framework suggests a number of possible drivers of adaptation. But it is recognized that the framework might not be comprehensive. Further exploration into additional factors which might influence adaptation can be done. Some factors might especially vary with different regional contexts around the world. Also, future research might work on comprehending the inter-relationships among the drivers. The present study assumes each driver to be independent as there was no significant correlation among them. But variables might have incidental impact on others, for example social capital can affect avenues for economic capital, and hence can have indirect influence on adaptation. Future empirical models can attempt to quantify such indirect effects. The present study has also not assessed the sustainability of the adaptation strategies. Uncontrolled mechanization and use of destructive fishing gears, such as trawl nets, can malign the marine ecosystem (Daw et al., 2009). This paper focuses on traditional fisherfolk, who have not majorly mechanized and understand environmental impacts of destructive fishing (as observed from the FGDs and survey). Hence, use of advanced gear is considered as an adaptation strategy for the community. But, it is acknowledged that appropriate management strategies must be planned to avoid over capacity of the sector.

This study is one of the first attempts to statistically recognize drivers of adaptation in marine fishing communities. The framework and findings are arrived at using multi-methods, including FGDs and an extensive household survey. The novelty of the paper is enhanced through the comparison of drivers in marine fishing communities with different regional backgrounds. Further, the framework of the study combines capitals and perceptions of stresses as possible drivers of adaptation. The study also suggests various interventions (Table 5) which emphasize the need of reviewing and implementing many of the existing policy measures by the various tiers of stakeholders. This study adds to the growing literature on appreciating the importance of differential adaptation decision-making in communities and have implications for designing capacity-building programmes.

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Appendix A, B and C. Supplementary data

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